

DEFORESTATION MONITORING IN THE COLOMBIAN AMAZON: SEMANTIC SEGMENTATION AND CHANGE DETECTION WITH DEEP LEARNING AND SENTINEL-2.

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Colombia stands out as one of the most biodiverse countries per square kilometre, hosting nearly 10% of the world's species within its varied ecosystems, where nearly 1,900 species of birds, 67 mammals, and more than 130,000 plant species are found.

AMAZON RAINFORESTS ARE IN BIG THREAT

123,517 hectares of forest lost in 2022, an area roughly equivalent to the size of Los Angeles or 1,200 km².

Effective and timely monitoring of these vast and often inaccessible regions is therefore not just a national priority but a global imperative.

REMOTE SENSING EMPLOYS SATELLITE IMAGERY TO OBSERVE AND QUANTIFY LAND COVER CHANGES ACROSS EXTENSIVE REGIONS.

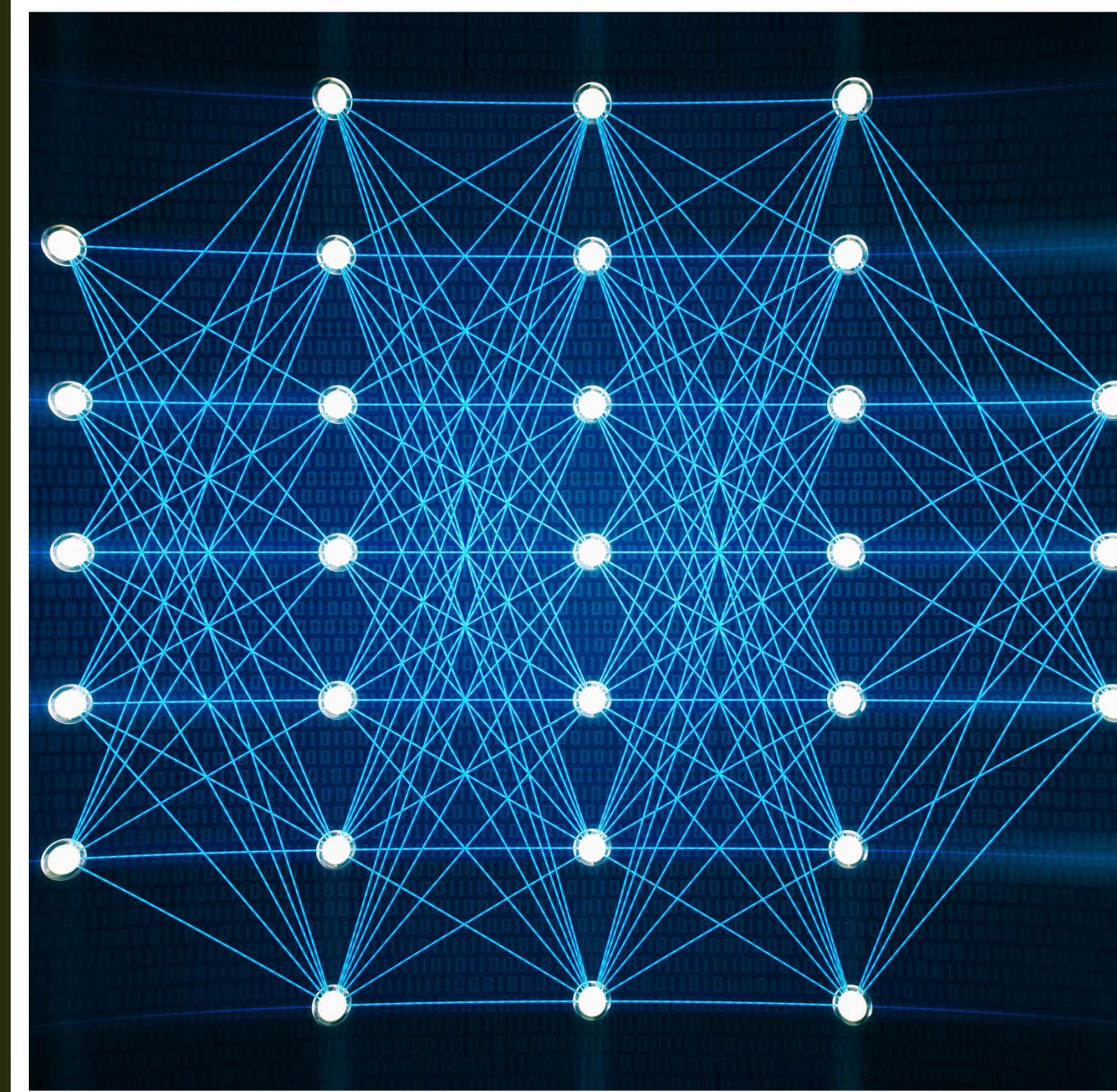
Limitations

- Cloud Cover
- Atmospheric Effects
- Interpretation





NEURAL NETWORKS TO THE RESCUE



CNNs have revolutionised the field by automatically learning hierarchical feature representations directly from raw image data.

Applications

- Time-Series Analysis
- Image Classification or Object Recognition
- Semantic Segmentation

Critical Bottleneck

The scarcity of large-scale, accurately labelled training data.



PRIMARY GOALS OF THIS WORK

1. Automated Pipeline for Training Data using GEE.

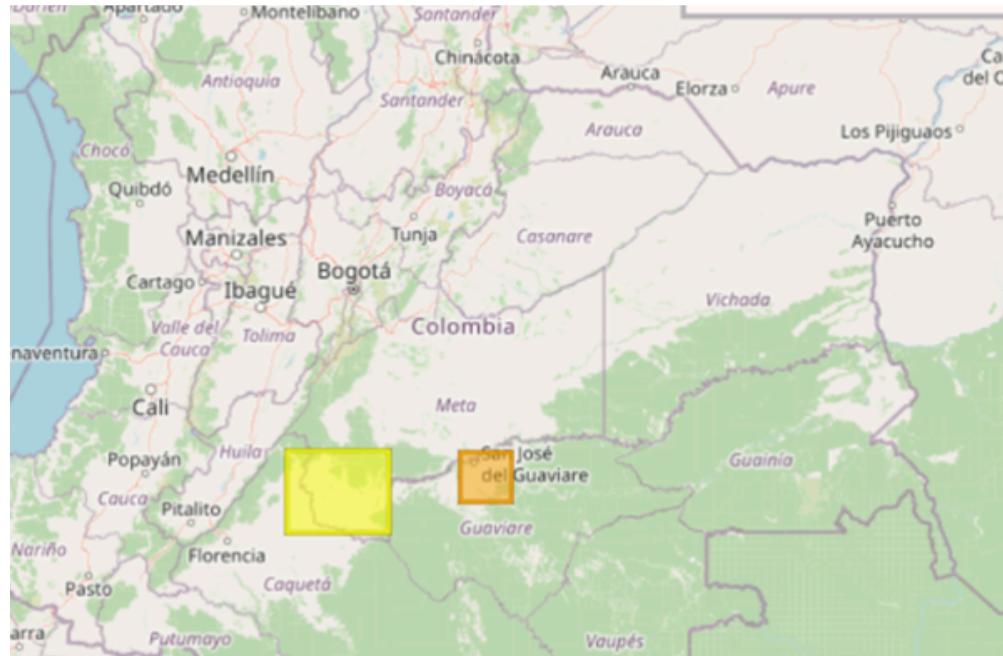
Design and implement a novel, automated pipeline combining Sentinel-2 and the Dynamic World dataset to generate large-scale training data for land cover classification.

2. Experimentation with Deep Learning

Test state-of-the-art deep learning architectures (U-Net and Attention U-Net) for semantic segmentation of land cover in the complex ecosystems of Colombia.

3. Change Detection Analysis

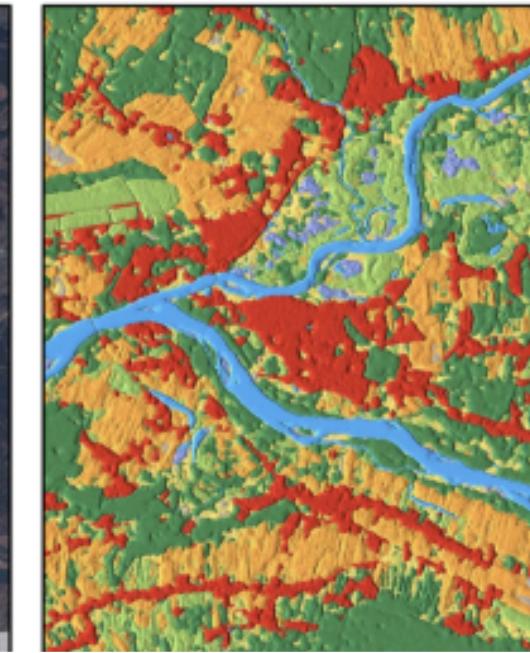
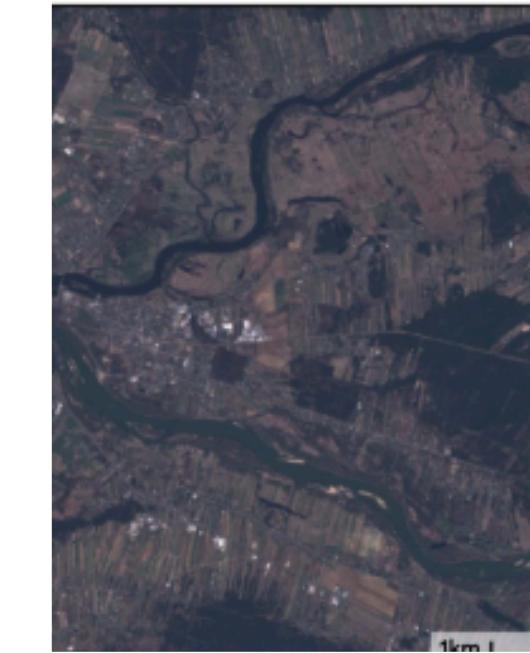
Produce a high-resolution land-cover map and a quantitative analysis of forest change for a critical deforestation hotspot, providing actionable insights for local conservation efforts.



Region of Study

Two regions encompassing municipalities consistently ranked as active deforestation hotspots were selected for the study:

1. San Vicente del Caguán & La Macarena
2. San José del Guaviare



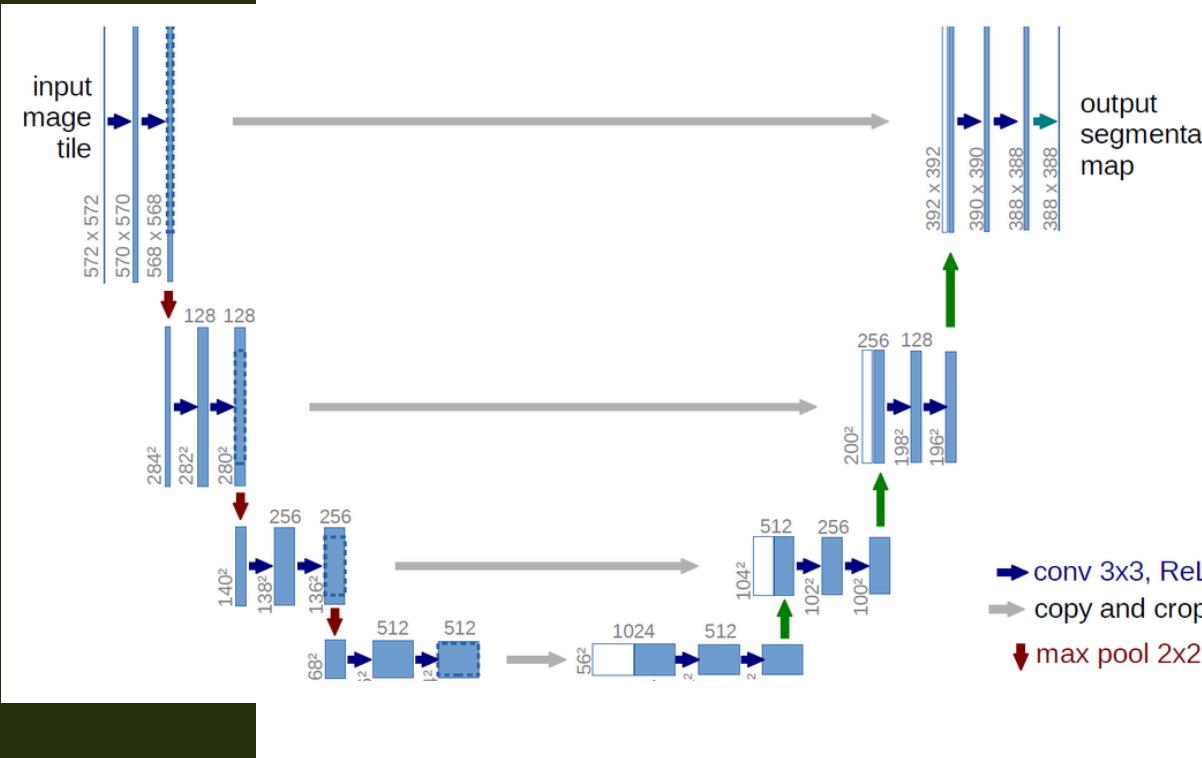
Sentinel-2 & Dynamic World

Two linked datasets from Google Earth Engine are utilized: Sentinel-2 imagery serves as input features, and Dynamic World land cover provides pixel-level labels for training and validation.

A cloud-free 2022 Sentinel-2 composite and Dynamic World labels were generated in Google Earth Engine. Classes were remapped, features were normalized, stacked, and exported as 256×256 TFRecord patches (2,279 total; 2,051 for training, 228 for validation).

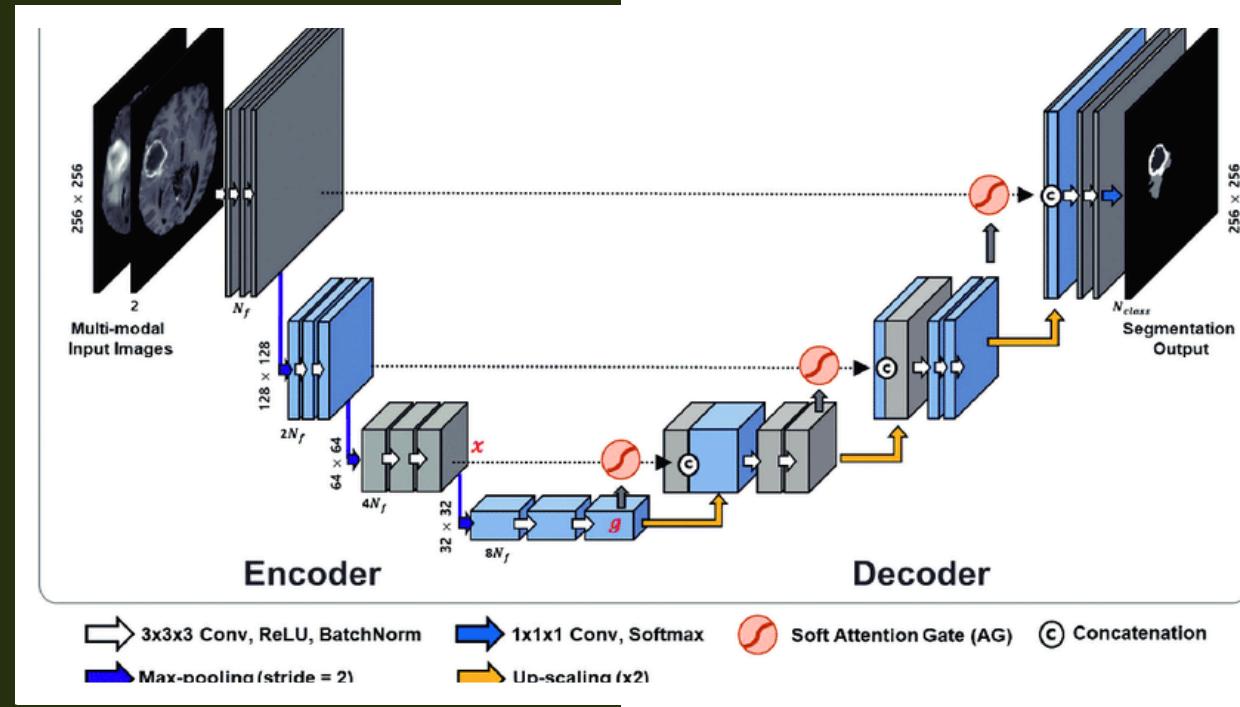


NETWORK ARCHITECTURES



U-Net

Type of CNN that has a U-shaped structure and compresses images to capture context and then expands them to recover details, using skip connections to combine both.



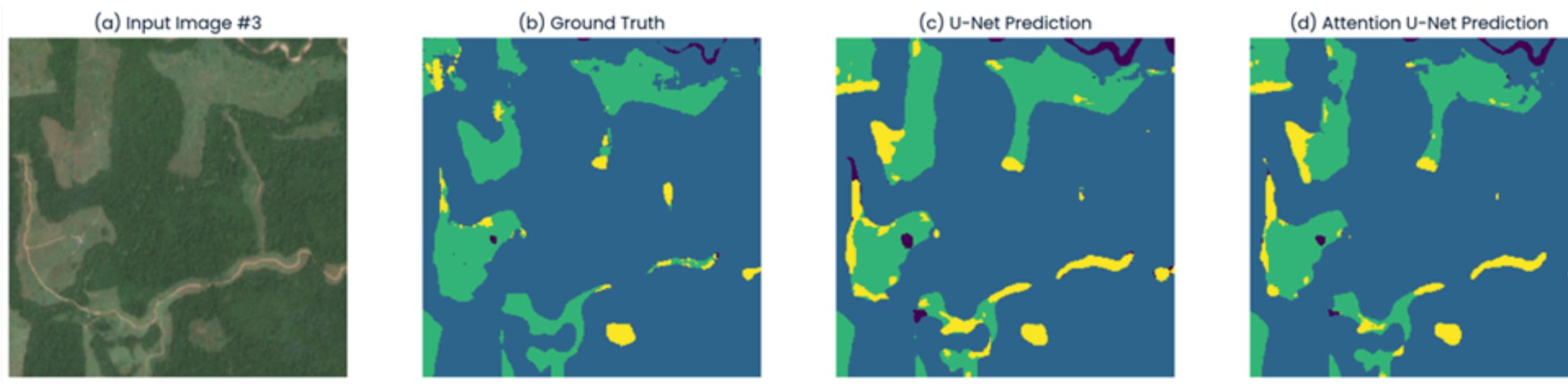
Attention U-Net

Adds “attention gates” to U-Net, helping the model focus on important regions, while ignoring background.



WINNER:

Attention U-Net emerged as the superior model, achieving a higher overall pixel accuracy.



Model	Precision	Recall	F1-Score	Overall Accuracy
U-Net	0.99	0.85	0.91	92.07%
Attention U-Net	0.96	0.90	0.93	93.47%



TRACKING FOREST CHANGE

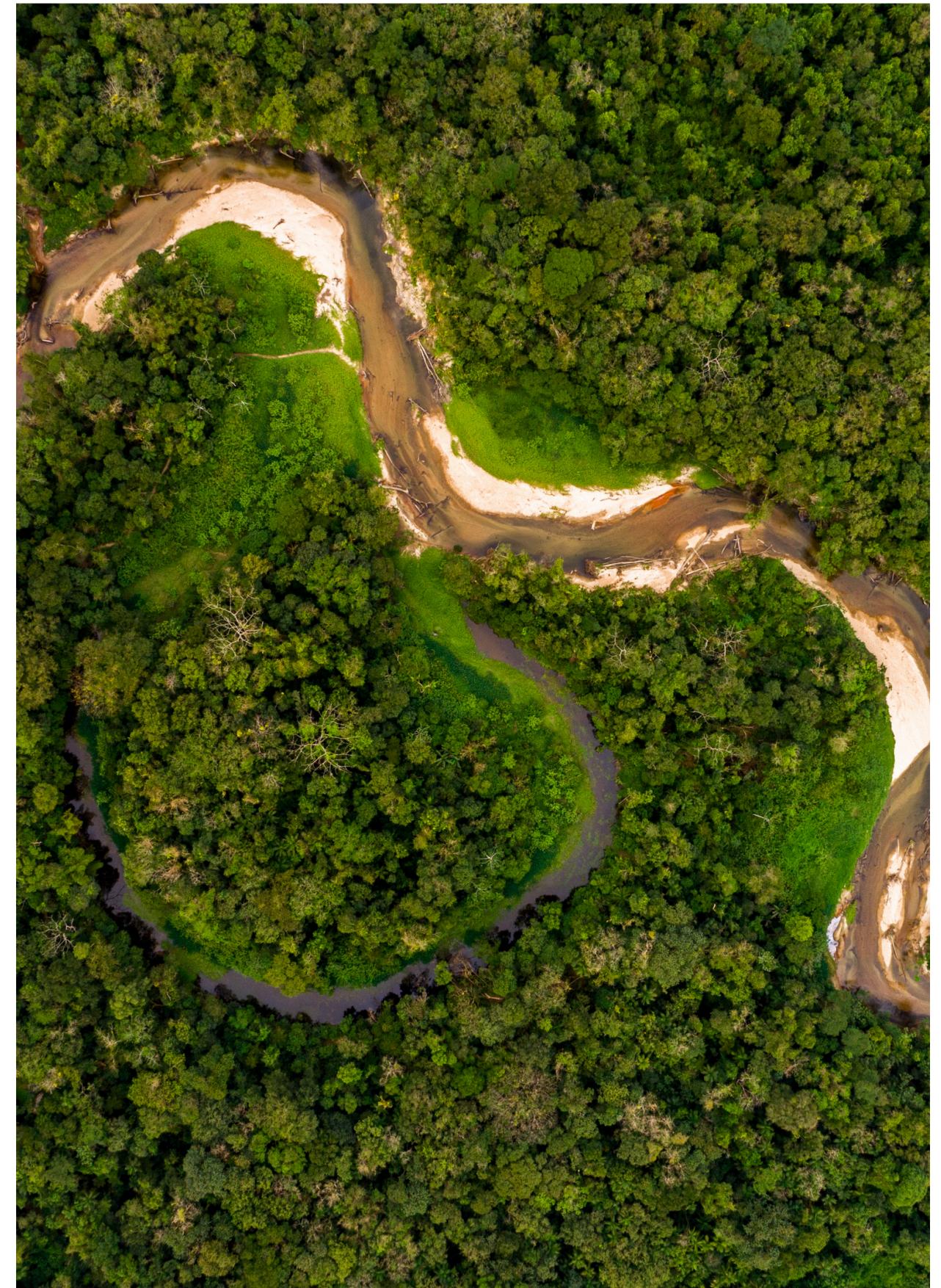
The top-performing model was selected for the final change detection analysis. It was used to compare land cover maps from 2021 and 2023.



The analysis identified land cover transformations over the two-year period. The model detected 232.15 km² of deforestation, reflecting a transition from "Forest" in 2021 to "Non-Forest" in 2023.

SUMMIT & HORIZON: DECODING AMAZON DEFORESTATION WITH DEEP LEARNING

- An automated deep learning pipeline was built for Amazon deforestation monitoring.
- Attention U-Net outperformed U-Net with higher accuracy and balance.
- Application revealed 232.15 km² of deforestation (2021–2023) in San José del Guaviare.
- Workflow is scalable, automated, and reproducible, supporting conservation efforts and policy decisions.





THANK YOU